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# TRADE ROUTES IN THE ECONOMIC GEOGRAPHY OF BOLIVIA

BY

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The economic condition of Bolivia has been so profoundly affected by two railway lines from the seacoast to the principal plateau towns, La Paz and Oruro, and the country is being so rapidly developed by other railway lines now building, that the Bolivia of but twenty years ago is almost completely transformed (Fig. 1). In this respect it

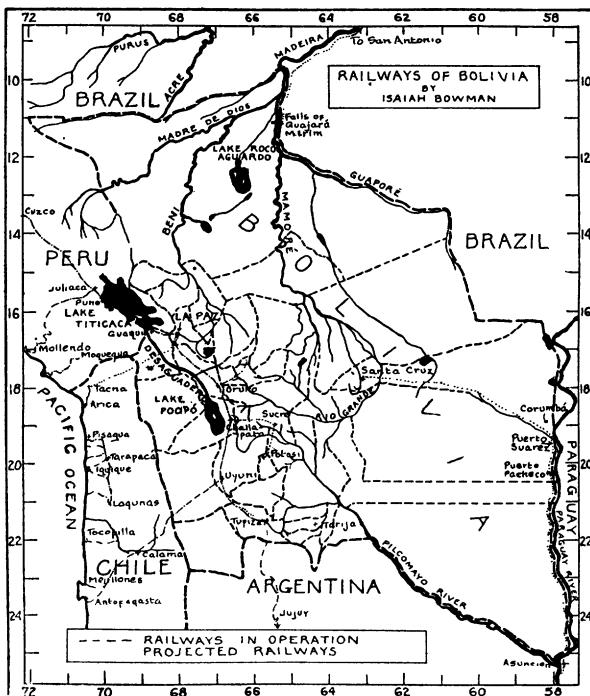


FIG. I.

compares with Mexico, whose industrial birth likewise dates from the completion of its first railway line to the United States, the line to the American frontier completed in 1884. In both countries the only general means of transportation until a comparatively recent

date were native carrier, pack train, and mule cart. In both cases a lofty tableland is the home of the white population and must be twice overcome in a single communication with the coast. Probably less than 7 per cent. of Mexico's population live on the lowlands of that country today.\* In Bolivia less than 12 per cent. dwell upon the eastern tropical and sub-tropical plains.† These figures can only be compared by first noting that more than two-thirds of Mexico is upland while nearly two-thirds of Bolivia is plain (Fig. 2). This



FIG. 2.  
From *Bull. Geog. Soc. of Phil.*, Vol. 7, No. 2, 1909.

reverses the density ratios and gives Bolivia a much thinner plains population than Mexico. Both countries were long obliged to develop their chief resource, their minerals, under the most stupendous disadvantages that the modern industrial world exhibits.

If Mexico's former difficulties are appreciated, by virtue of our better acquaintance with a nearer neighbor, Bolivia's former difficulties may be best understood by noting that the tableland of Bolivia

\* Costa Rica. G. E. Church. *Geog. Journ.*, Vol. 10, 1897, p. 76.

† Approximation, based on data from *Geografía de la República de Bolivia*, tables in handbooks of S. A., and other sources.

is from one and a half to two and a half times farther from the coast than is the tableland of Mexico and half again as high; and whereas the railway from Vera Cruz to Mexico City climbs to 7,200 feet, in crossing the edge of the tableland, the two lines from Mollendo and Antofagasta ascend to 14,666 feet and 13,700 feet, respectively, in order to reach Bolivia. Furthermore, once the coast of Mexico is gained, a comparatively short ocean voyage at cheap rates places her products in the markets of the largest industrial centers of the world; on the other hand the distance from Bolivia's western outlet ports on the Pacific to New York, by way of the Straits of Magellan, is several thousand miles farther than the direct distance from those ports to the North Pole.

What the isolation and loftiness of the Bolivian situation formerly meant may be illustrated by a few specific examples which will at the same time prepare the way for a discussion of existing transportation conditions and methods in those parts of the country that are not served by railways. In 1884, for instance, all the ores and metals of the Serranía de Guadalupe district in southern Bolivia were transported by mules and donkeys through Argentina to the port of Rosario,\* approximately 1375 miles. One mine had been abandoned after the investment of £30,000. Pasley asserts† that he saw the bills of lading at the establishment, from which it appeared that £7,000 had been spent on freight alone from the port of Rosario. Nearly up to the time of the completion of the railway to Oruro from Antofagasta in 1892 the silver and tin of Potosí were transported to the Pacific seaboard, 500-575 miles away, by pack-train and mule cart at incredible cost, the returning caravans bringing back merchandise over the same steep and difficult way. In 1882, Minchin wrote‡ that the rate from Oruro to Tacna, the interior terminus of the railroad from the port of Arica (250 miles) was £15 per ton. Yet at that time the silver output of the country, in spite of these enormous disadvantages, was \$8,000,000 to \$10,000,000 annually. Ores containing 1 to 1½ per cent. of silver were more advantageously exported to Europe, in spite of high freight rates to the coast, for the value of the accessory minerals, copper, tin, etc., was often in itself sufficient to cover the total cost of transportation. There are more than 10,000 abandoned silver "mines" in Bolivia today.§ They were for the most part abandoned because of lack of capital or labor,

\* Descriptive Notes on the Southern Plateau of Bolivia and the Sources of River Pelaya. C. M. S. Pasley. *Geog. Journ.*, Vol. 3, 1894, pp. 105-115.

† *Ibid.*, p. 109.

‡ The Tableland of Bolivia. *Proc. of the Royal Geog. Soc., London*, Vol. 4, 1883, pp. 671-676.

§ *Bull. Int. Bureau of Am. Repub.*, July, 1908, p. 72.

or both, or on account of ruinous transportation rates, or the flooding of the mines by water on account of the primitive mining methods employed. Among these factors, lack of good transportation facilities stands preëminent. The tax is not only upon the hauling of the mine products to the railway but also upon the enormous cost of machinery and materials of all sorts, especially fuel.

Mining development has often meant an increase in the cost of merchandise imported for general use. In 1861 the freight rates from Cobija, in what is now northern Chile (then Bolivia), to Calama in the Loa valley, 120 miles toward the northeast, were \$8 per *carga* of 300 lbs. When the mines at Caracoles, 90 miles east of Cobija, were opened, they competed so successfully with the merchants for carts and mules for ore transportation that the cost per *carga* of 300 lbs. rose at once to \$15. In 1871 the freight rates from Potosi to Calama (450 miles) were \$30 per mule load of 300 lbs. The cost was due partly to the direct labor of transport and partly to the exceptional lack of pasturage and water, forage being a considerable part of the original cargo. The cost of moving a piano (400 lbs.) from Cobija to Potosi (575 miles) was then \$320 to \$350. To Sucre the price was \$60 to \$80 more. The freight on a single mule load of bottled beer was \$36 to \$42 from either Tacna or Cobija to Potosi. The price of goods conveyed by caravan was often increased 100 per cent. in the transit across Atacama and the western Andes to the central plateau. In other words, the average cost of taking a ton of goods from Europe to the central cities of Bolivia by these transportation methods was equivalent to the transportation of the same ton a distance of 20,000 miles by railway at average rates or six times the circumference of the earth by steamship.\* These examples will serve to explain why nearly every student of Bolivia's transportation methods finds conditions there today and in the recent past so interestingly similar to that period in our own industrial development west of the Mississippi, in the '50's and later, when bullock cart and prairie schooner were being replaced by railroads.

The early cart roads and mule paths to the coast are of added interest because they are the routes of the railways either now completed or building. The number of these routes to the frontier and the coast was and is very definite, for there are few natural ways out of the country and these have all been used for centuries past. They will be taken up in turn for detailed discussion. The routes are briefly named and characterized as follows (Fig. 3):

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\* The Route to Bolivia *via* the River Amazon, pp. 143, 148, 149, *et al.* G. E. Church, London, 1877.

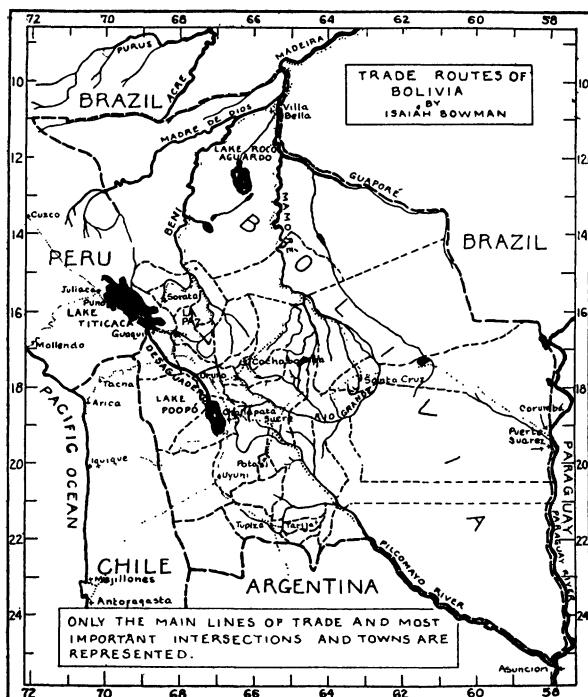


FIG. 3.

**MOLLENDO-LA PAZ.** From La Paz, capital and largest city of Bolivia, over 500 miles west, to and across Lake Titicaca, and over a high tableland, lofty mountains, and the coast desert, to the port of Mollendo in southern Peru.

**ARICA-LA PAZ.** From La Paz, through similar country, to Arica in Chile. This route would eliminate the double handling now necessary in crossing Lake Titicaca. Furthermore, the distance is shorter and the grades far more favorable. The port of Arica far surpasses Mollendo, both in size and security. It would bring La Paz within twelve hours of the coast.

**IQUIQUE-ORURO.** From Oruro, on the alto planicie (high plateau) of Bolivia, 150 miles south of La Paz, west to Iquique on the Chilean littoral. Reasonable grades but an unproductive country. Route could not compete with Arica or Antofagasta.

**ANTOFAGASTA-ORURO.** Oruro is now connected with Antofagasta by a meter gauge railway completed in 1892. It has been the sole railway outlet for southern Bolivia, as the La Paz-Mollendo line has been for northern Bolivia, until the recent opening of the line from

La Paz to Oruro. This short connecting link now allows a choice of routes for plateau commodities.

ARGENTINA-BOLIVIA. The road from Tupiza to Uyuni is now being completed. It follows stream valleys from the northern pampas in Argentina to Jujuy and through the southern border of the tableland of Bolivia to Tupiza and thence to Uyuni on the Antofagasta-Oruro line with which it will connect for northern Bolivia.

PLATEAU-PLAINS. Three related projects eastward from La Paz, Cochazamba and Sorata, have as their common object the opening of the eastern tropical plains of Bolivia to the plateau and the better connection of both plateau and plains with the Amazon and the Atlantic. The conquest of the eastern Andes and of the falls of the Madeira are important parts of this comprehensive scheme. It is unlikely that more than one line will ever be constructed.\*

PARAGUAY-SANTA CRUZ. Surveys are now being prosecuted west of Corumbá on the Paraguay for a railway that shall connect Santa Cruz de la Sierra with the Paraguay. It is within the scope of Bolivia's present railway scheme to extend the plateau lines eastward to Santa Cruz which, if accomplished, would give Bolivia uninterrupted passage from the Pacific to the Atlantic.

#### MOLLENDO-LA PAZ.

The well-known Mollendo-La Paz line may be described briefly. It was begun in 1870 and completed to Lake Titicaca in 1874 and later to La Paz the capital. Formerly this was one of the caravan routes to northern Bolivia, and competed for supremacy with the route from Arica. The latter way, being shorter, was the more important, however, until the completion of the railway line, when it immediately dropped to small importance except as a mail route to Tacna and Arica. The La Paz mails are delivered to Tacna by swift coaches in five days and as even the railway journey from La Paz to Mollendo requires three days and European steamers are often as much as a week apart on the west coast it can readily be seen why this route frequently means an earlier mail to Europe than that to Mollendo and is therefore maintained.

It was an early aspiration of the best Peruvian statesmen to see

\* The location of the principal custom houses of Bolivia will indicate the principal routes and the relation of the railways to the main lines of trade. They are as follows: Guaqi (Lake Titicaca), Oruro (the only large plateau city on the Antofagasta-Oruro line), Uyuni (at the point where the caravan trail from Argentina strikes the railway), Tupiza and Tarija (on the way from Argentina to Southern Bolivia), Puerto Suarez, Villa Bella, Abuna, Madre de Dios, and Bahia, on the eastern rivers of Bolivia for the collection of heavy export duties on rubber, chocolate, etc., and the lighter import duties on merchandise.

all the wealth which was originally carried by llamas and donkeys to the coast from Bolivia borne across Lake Titicaca by steamers and across the cold Maritime Cordillera by railroads. The interesting features of the early attempts in this direction were noted by Markham in 1874.\* In the '40's an attempt was made by Costas to place a small steamer on the lake. He foresaw the important trade this would both create and serve. The products of the Peruvian and Bolivian forests and eastern valleys—timber, cinchona bark, chocolate,



FIG. 4.  
From *Bull. Geog. Soc. of Phil.*, Vol. 7, No. 2, 1909.

coffee, coca, fruit, rubber, etc.,—would be conveyed to the coast; the European manufactured goods and the sugar of the Peruvian coast valleys would be imported into Bolivia; a brisk trade in wool, silver, copper, and tin, would follow, and a local traffic in provisions. In 1861 the Peruvian government ordered two screw steamers in London, called the "Yaravi" and "Yapura." They were 20 ton boats of 40 H. P. and were sent out in pieces to the port of Arica, thence to Tacna by rail and finally across the Andes on the backs of mules to Puno,

\* Railways in Bolivia. *The Geog. Mag.*, Vol. 1, Apr., 1874, pp. 36-41.

the port at the western end of Lake Titicaca. Several pieces were lost and the project was in abeyance until 1868 when Captain Melgar of the Peruvian navy was appointed to complete the work. He brought up workmen and materials from the coast to the port of Puno and there, in the total absence of all local resources, built a factory and a mole and launched one steamer in June, 1871, the other in March, 1872.

The railroad from Arequipa to Lake Titicaca was constructed by the Napoleon of Peruvian railroad engineering, Colonel Meiggs. He contracted for the line at £6,400,000 or £29,500 per mile. The cost of transport, and of the labor, materials, and provisions was of course enormous. Embankments from 50 to 500 feet high are numerous. In one place there is an 84-foot cut on a hillside with the roadway 1,000 feet of almost perpendicular height above the valley. The distances to water are often long, and from Arequipa to the baths of Yura, seventeen miles, the water was conveyed by mule-back. At Caniaguas it was carried twenty-six miles. The cold of winter at high altitudes is intense. The work was begun in June, 1870; from 4,000 to 5,000 laborers, mostly Chilians and Bolivians, were constantly employed for 3½ years; and on Jan. 1, 1874, the first locomotive reached the shores of Lake Titicaca, 12,500 feet above the sea. The highest point on the old road from Arequipa to Puno is 15,590 feet, that of the present railroad 14,666 feet (Crucero alto).

The building of the northern railway line meant the commercial rehabilitation of the entire region. For not only did it become possible to develop enterprises on the immediate line of the railway but many rich mining claims some distance from the railway, formerly impossible of development because of high freight rates, were found to be commercial possibilities even with mule transportation to the railroad. This principle of dependence of industrial enterprises upon proper means of transportation is abundantly illustrated by every railroad venture in the Republic. Even today there is vast mining development in the country away from the railways, which is possible because of the saving in long hauls to the coast that the part-rail shipments effect. Thus the rich tin mines at Huynuni, 30 miles from the railroad at Machacamarca, ship their concentrates by mule cart down the Huynuni valley and haul in their machinery, much of it extremely heavy, by the same route. Similar illustrations are abundant. Such mining development should not however be thought ideal. The expenses for the additional men, animals, and forage; the breakdowns, the limitations set upon the size and weight of machinery, the delays from swollen streams, and the trans-shipments,

these are but a few of the difficulties which the practical engineer of the region must meet.

One of the best illustrations of the expense incident in some localities on transshipment alone, are the copper mines at Coro-Coro. The partially treated ore from these properties is hauled in mule carts about 20 miles to the Desaguadero River where it is shipped in barges to Guaqui, the port at the eastern end of Lake Titicaca. It is then taken by lake steamers 140 miles to Puno; by freight train to Mollendo, the Pacific port; by barge from the wharf to the steamer

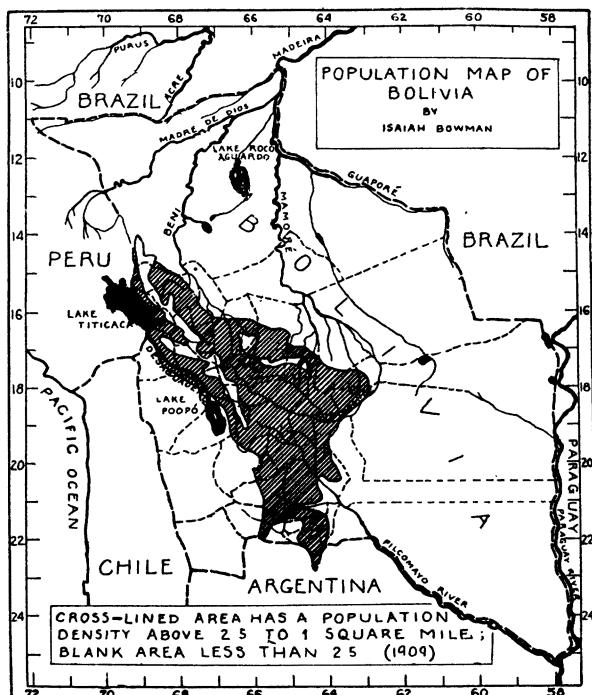


FIG. 5.

From *Bull. Geog. Soc. of Phil.*, Vol. 7, No. 2, 1909.

conveying it to its final destination in southern Chile or Europe or the United States: counting the mining operation, the ore is handled *eight* times before delivery to the smelter. The locomotives, steel rails, ties, in fact all the material for the railroads now building in Bolivia must be unloaded into barges from the ocean steamers, after the voyage from the United States, then to the freight trains on the wharf, by rail to Puno, by steamer to Guaqui, and again by rail to the construction camps at the end of the line. What this means in

the case of heavy machinery and steel rails so awkward to handle can better be imagined than described. Every pound of coal must come by the same route at similar expense. Every tie (from Oregon and California) in the Viachi\*—Oruro line costs \$2 gold.

The Mollendo-La Paz line is of additional service because it made possible the branch to Oruro which is now completed and connects the two largest cities of Bolivia. Construction work has also been carried some distance toward Cochabamba and Potosi. The junction of the capital with Oruro brings about a political solidarity, itself as important for Bolivia's economic development as the railroads are important in their industrial effects. Four large cities, centers of as many great population groups, have developed in distinctly separate parts of Bolivia *viz.*, La Paz, Oruro, Cochabamba, and Sucre (Figs. 4 and 5). Revolutions have in the past gained dangerous headway in consequence and have been difficult to stamp out because of the distances to be overcome through the barren tracts that separate the various population groups. Quick transportation between Oruro and La Paz now gives these cities and the high plateau groups of people a balance of power over Sucre or Cochabamba acting individually. The extension of the railway to Cochabamba would effect still further consolidation politically; and, by offering cheaper communication, would lead to better acquaintance and greater friendliness than has heretofore been possible (Figs. 6 and 7).

#### ARICA-LA PAZ.

Few railway projects in South America have been considered more frequently and seriously than that from Arica to La Paz, and none seems to be subject to more discouragements. The surveys from Tacna, the present interior terminus of the railway, have been made and actual construction has been begun repeatedly only to be delayed by the financial difficulties of the several companies. The latest contract has been awarded by the Chilean government to a German bank for £3,000,000.† The bank's interest in the matter ceases with the taking of the Government 5 per cent. bonds that are to be issued for the construction of the road. The line will be about 335 miles long and will be completed in four years according to the terms of the contract. The work is to be done in five sections. The government is to provide the right of way and,

\* The station on the Molendo-La Paz line, 40 miles east of Guaqui, on Lake Titicaca, from which the Bolivia railway runs south to Cruso.

† Daily Consular and Trade Report, Jan. 30, 1908, No. 3087.

as is customary in railway construction in this section of South America, is to admit duty free all material and machinery used in the construction of the road. It is built in accordance with the terms of a treaty made between Chile and Bolivia, March 21, 1905, whereby Chile finally took over that portion of Bolivia which formerly bordered the Pacific.\* The rich mineral resources of the section which

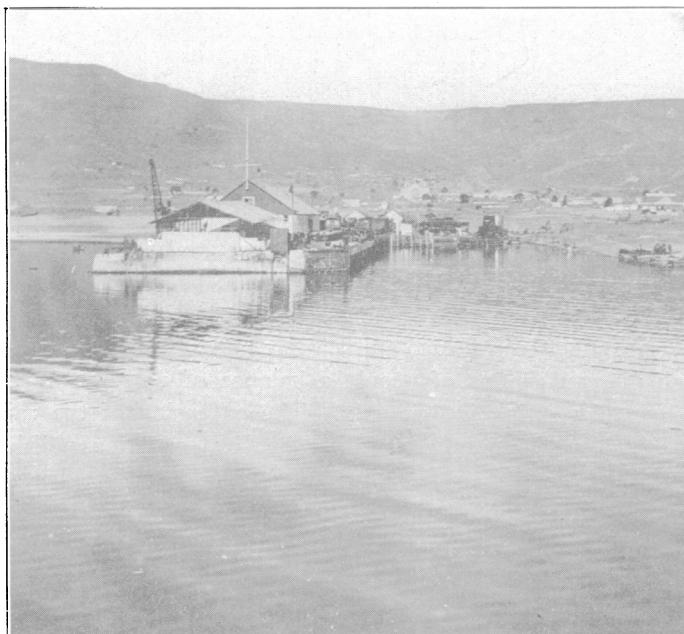


FIG. 6. THE PORT OF PUNO.

At the western end of Lake Titicaca. It is the eastern terminus of the railway from the coast at Mollendo, Peru. Steamers connect Puno with the port of Guaque at the east end of the lake, where there is direct rail communication with La Paz.

the line will serve will mean much for both Chile and Bolivia and besides this there will be introduced a competitor to the Southern Railway of Peru now enjoying a monopoly of the trade of northern Bolivia.

#### IQUIQUE-ORURO.

The third route is one which has never been seriously considered as an actual rail route by the railway promoters of South America. The suggestion of the route is owing to Minchin† who called attention to the easy and regular grade of the western slope of the

\* See any map of Bolivia prior to the war of 1880, or the treaty of 1883.

† The Tableland of Bolivia. *Proc. of the Royal Geog. Soc., London*, Vol. 4, 1882, pp. 671-676.

Andes east of Pica, an oasis 14 miles from the nitrate railway to Central Lagunas, in the province of Tarapacá, northern Chile. Our own observations show that the direct grades are here from  $3^{\circ}$  to  $7^{\circ}$  to an altitude of 14,500 feet and the topography and drainage along the route are favorable for the easy construction, by moderate curves, of grades below the lesser value. This railway would have to reach an altitude of nearly 16,000 feet if it crossed the Sillilica range and entered Bolivia via Cueva Negra and Cancosa, but only 14,000 feet if it entered the interior basin south of the volcano Sacaya by way of the borax lake, La Queca, and the town of



FIG. 7. THE PORT OF GUAQUI, LAKE TITICACA.

A dredged channel is maintained between the docks and the open lake, for the lake border is here fringed with extensive marshes.

Canquilla. The road could be constructed for much less than it cost to build either the Antofagasta or the Mollendo line. There are no towns of consequence along the route, merely isolated mountain villages of shepherds who supplement the resources of their flocks by cultivating such alluvial fans as can be irrigated. The chief advantage of such a line would lie in the development of the rich mineral deposits known to occur throughout much of this section of the Maritime Andes, a development that waits absolutely upon the cheap transportation which only the railroad can bring. The existing

trade over this route is in millet, firewood, wool, and skins brought down by the mountain Indians in llama caravans to the oases on the eastern edge of the desert of Tarapacá-Pica, Matilla, Macaya, etc., and there exchanged for cloth, alcohol, fruits, candles, and a host of lesser articles. The trade, while regular, is not considered important enough to warrant the maintenance of a custom house, and smuggling is not only the rule but is winked at by both Chile and Bolivia.

#### ANTOFAGASTA-ORURO.

Before the construction of the railway (completed to Oruro in 1892), over this ancient route, caravans from all that part of the altiplano,\* of Bolivia between Potosí and Tupiza converged at Calama, a well-watered oasis in the Loa valley and now a station on the railway a day out of Antofagasta. From Calama two routes led out to the coast, one toward Tocopilla, now an active nitrate port, the other toward Antofagasta and Mexillones. The railway has taken advantage of the same depression in this part of the Andes that guided the routes of the earliest caravans to Calama, a town of several thousand inhabitants. Thence it ascends to a 13,700 ft. pass north of the twin peaks, San Pedro and San Pablo, to enter the great central basin *via* the borax lake, Ascotan. The Lake has an area of 60 or 70 square miles and lies between the volcanic peak of Ascotan and Ollague. The "lake" is really a bed of borate of soda with numerous scattered pools of salt water. The salt crust is from 2 to 7 feet thick and so firm that the old cart road to the coast passes over it. A borax establishment has been manufacturing the deposit on a large scale since the introduction of the railway.

Among the industrial readjustments which the railroad has effected none is more interesting than the retrogressive effect which for a short time the railroad had upon the oasis of Calama (Fig. 8). When it lay on the route of the caravans between seacoast and interior its fertile fields and luxuriant pastures were a source of great wealth to those owners who supplied forage to the pack mules. As soon as this caravan trade was largely supplanted by the more efficient railway service, Calama became only a way station on the railway and was obliged to become self-dependent. While, by virtue of its position, it still attracts the caravan trade of a small district toward the southeast, it is to a much larger extent deprived of the advantages of its former trade relations. For a short time this loss of strategic position was keenly felt, but the recent rapid development of the

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\* The name given to the high plateau of Bolivia. Often called altiplanicie, central basin, central plateau, etc.

nitrate establishments on the nitrate pampa of Antofagasta has once more stimulated the production of forage for the thousands of mules employed on the caliche carts of the nitrate works, and Calama is now without exception the chief hay producing centre in the whole northern half of Chile. It is correspondingly prosperous, as may be

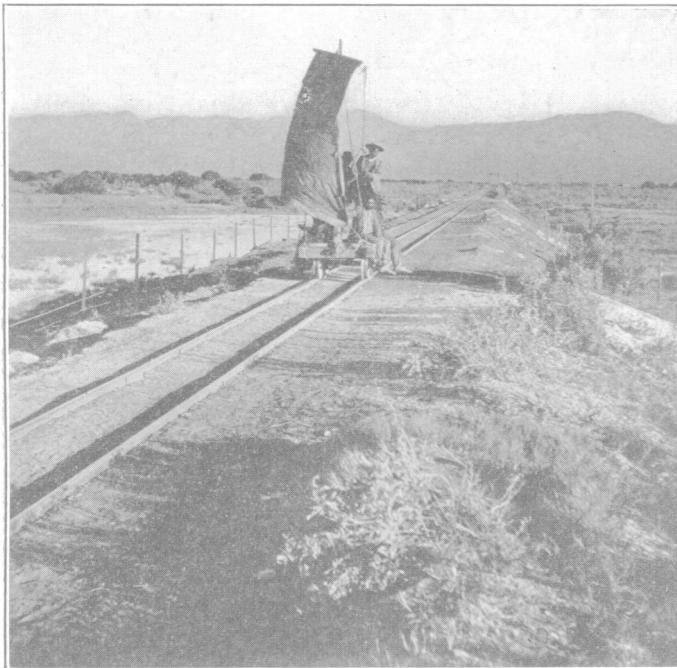


FIG. 8. SAIL CAR.

On the Antofagasta-Bolivia railway near Calama, Chile. The workmen take advantage of the almost constant winds to run into port at nightfall, literally "blowing into town."

appreciated when one considers the utter barrenness of the nitrate region of Antofagasta and the necessity of importing from southern Chile and Calama the entire forage.

Until the completion of the line between Oruro and La Paz (1908-1909), trains ran daily as far as Calama, but only three times a week from there to Oruro. The gauge is but one meter and the rolling stock of rather a primitive sort, though Pullmans have lately been introduced and the time between Oruro and the coast shortened. The port of Antofagasta is habitually congested and the mine owners of the interior complain constantly of the lack of ore cars for coastal shipments (Fig. 9). This deficiency, whether due to the defective administration of the road or to the actually great amount of traffic,

would be remedied by the competition which the Uyuni-Tupiza line, when completed, would afford. The present condition of the traffic may be judged from the fact that a copper smelter at Calama is able to supply itself with machinery only after the lapse of at least a year. Six months have to be allowed for the delivery at Antofagasta of consignments of machinery from Liverpool and six months for the day's journey to Calama. It may confidently be stated that, unless the gauge is widened and the rolling stock and service improved, the mining development of the region served by the line will soon be unable to increase, notwithstanding the invaluable service which the railway has in the past rendered both the nitrate industry

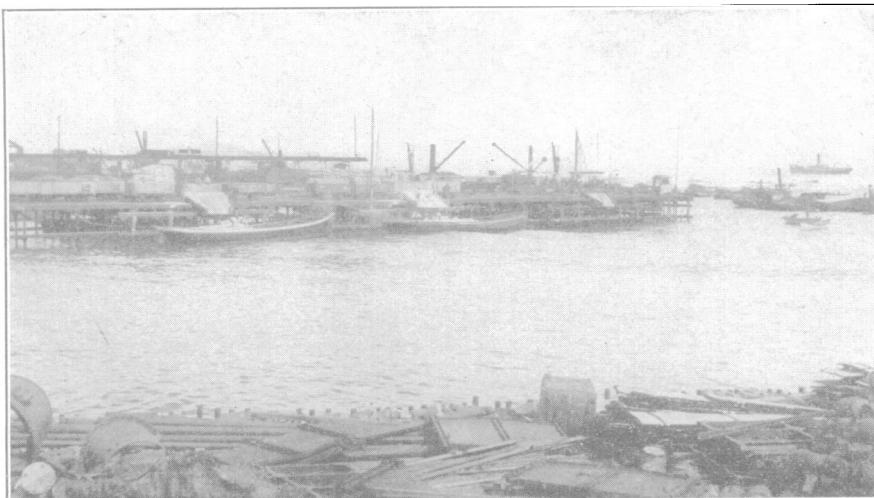


FIG. 9. THE PORT WORKS AT ANTOFAGASTA.

Steamers anchor off-shore (right background) and the cargo is discharged by means of lighters shown tied to the docks. The sacks on the wharf are filled with nitrate.

of the coast and the mines of the interior. The alternative would be the completion of rival railways on the plateau. But such competition can no longer be expected, as certainly was expected when the Bolivia Railway Co. was first organized.

The original plan of operation of the Bolivia Railway Co. frankly included competition with the Antofagasta and Bolivia Railway Co. (Limited). To the north it would connect (at Viachi) with the Mollendo-La Paz line and, to the south, via Potosi and Tupiza, with the Argentine system at La Quiaca. This whole arrangement has, however, been upset by the fact that on Dec. 1, 1908, President Montes of Bolivia signed a bill, recently passed by the Bolivian

Congress, embodying changes in the original concession of the Bolivia Railway Co. The changes were made at the request of the American syndicate building the road. It is a step toward the consolidation of the interests of these two roads and will undoubtedly result in the unification of the railway systems of Bolivia. By the terms of the agreement now embodied in the law, the British company (The Antofagasta and Bolivia Railway Co.) guarantees the interest on the new line of the American company (The Bolivia Railway Co.) just completed between Viachi and Oruro, and makes a payment to the American syndicate for a majority of the new line's stock. The original terms of the American syndicate's concession were still further modified with reference to the remaining lines now projected or actually under construction. It is the general purpose of these changes to make the new lines serve as feeders instead of competing lines to the Antofagasta Railway.\*

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\* *Bull.* of the Intern. Bureau of Am. Republics. Jan., 1909, p. 111 *et seq.* ¶

(*To be continued.*)

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## THE EXPLORATION OF THE UPPER AIR\*

BY

ANDREW WATT, M.A., F.R.S.E.,  
Secretary to the Scottish Meteorological Society.

Much light has been thrown upon the movements and conditions of the higher atmosphere by observations made upon mountain summits, such as Ben Nevis, and we hope that some day there will be again a high-level station somewhere in the British Isles—supported by Government. It is indeed true that observations made upon mountain peaks and those obtained from some point in the free atmosphere represent different sets of conditions, and that the presence of the mountain itself affects the records. For example, it is probably true, as a rule, that the air on a mountain summit is

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\* This excellent summary of the nature and results of researches in the free atmosphere, made during the past few years, is reprinted from the annual *Journal* of the Scottish Meteorological Society, Edinburgh, Vol. 15, 3d Series, No. 26. The footnotes give references to publications in which may be found the original accounts of these researches. The *Bulletin* is indebted to Mr. Watt and the Scottish Meteorological Society for the opportunity to reprint this paper dealing with, perhaps, the most brilliant chapter in the history of meteorology.